(2)

AL-TR-1991-0049

AD-A235 689

"ARMSTRONG LABORATORY

ARMSTRONG LABORATORY

WATER VULNERABILITY ASSESSMENTS

John G. Garland III, Major, USAF, BSC

OCCUPATIONAL AND ENVIRONMENTAL
HEALTH DIRECTORATE
Brooks Air Force Base, Texas 78235-5000

April 1991

Final Report

Approved for public release; distribution is unlimited.

91-00493

91 5 24 020

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235-5000

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated, or in any way supplied the drawing, specifications, or other data, is not to be regarded by implication, or otherwise, as in any manner licensing the holder or any other person or corporation; or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The mention of trade names or commercial products in this publication is for illustration purposes and does not constitute endorsement or recommendation for use by the United States Air Force.

The Public Affairs Office has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nations.

This report has been reviewed and is approved for publication.

Air Force installations may direct requests for copies to this report to: Armstrong Laboratory, Occupational and Environmental Health Directorate Library, Brooks AFB TX 78235-5000.

Other Government agencies and their contractors registered with the DTIC should direct requests for copies of this report to: Defense Technical Information Center (DTIC), Cameron Station, Alexandria VA 22304-6145.

Non-Government agencies may purchase copies of this report from: National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield VA 22161

JOHN G. GARLAND III, Maj, USAF, BSC
Chief, Water Quality Branch

EDWIN C. BANNER III, Col, USAF, BSC
Chief, Bioenvironmental Engineering Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
April 1991

3. REPORT TYPE AND DATES COVERED
Final

4. TITLE AND SUBTITLE
Water Vulnerability Assessments

5. FUNDING NUMBERS

6. AUTHOR(S)
John G. Garland III, Maj, USAF, BSC

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Armstrong Laboratory
Occupational and Environmental Health Directorate
Brooks AFB TX 78235-5000
(Formerly: AF Occupational and Environmental Health Laboratory (AFOEHL))

8. PERFORMING ORGANIZATION REPORT NUMBER
AL-TR-1991-0049

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Same as Blk 7

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Statement A. Unlimited, approved for public release

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
Air Force regulations require the Medical Treatment Facility Commander to assure water vulnerability studies are conducted for employment sites and fixed installations. This technical report describes the emergency water planning program used by civilian water utilities. It also discusses proposed civil engineering plans for Energy Vulnerability Assessments within the Air Force. Both approaches operate in a similar manner--identifying threats, evaluating the impact of each threat, comparing supply and demand, correcting deficiencies. The report summarizes planning data for water consumption, discusses chemical and biological agent hazards and their treatment, and summarizes short-term water quality standards. The report recommends Bioenvironmental Engineers work closely with civil engineering on all aspects of base potable water emergency planning, but to focus their vulnerability study on medically-related areas.

14. SUBJECT TERMS
Emergency Planning, Water Vulnerability
Contingency Water Plans Garland

15. NUMBER OF PAGES
42

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102

(This page left blank)

Contents

ILLUSTRATIONS

I. INTRODUCTION

A. Purpose: AFR 160-25, Medical Readiness Planning and Training, tasks the Director of Base Medical Services to assure food and water vulnerability studies are conducted for employment sites and fixed installations. Bioenvironmental engineering personnel normally perform the water vulnerability studies.

B. Problem: The Bioenvironmental Engineer does not have technical information readily available for performing a vulnerability assessment. Furthermore, there is little supplemental guidance to the regulation about the scope and content of vulnerability studies. Complicating the matter further is the division of responsibilities within the Air Force for emergency water utility planning, with both the civil and bioenvironmental engineers having a role.

C. Scope: This report contains technical information on vulnerability assessment programs used in the public sector and information from the Air Force Civil Engineering draft guide for vulnerability assessments. (HQ AFESC/DEM anticipates publishing the final guidance in FY 92.) The report presents a number of protective measures that bases could implement to help eliminate potential water shortages. It also presents reference material for toxic pollutants in water supplies, protective measures, and emergency countermeasures. The conclusion lists elements which should be included in the BEE's vulnerability study. Appended to the report is a sample of an emergency planning document which would be generated if a CONUS base were to follow the steps in civil emergency planning.

II. DISCUSSION

A. Background

1. Emergency water planning guidance for bases is available from the public sector and through draft guidance from the HQ USAF AFESC community on utility vulnerability planning. Other documents, less widely distributed, contain bits of technical information on a wide variety of subjects from water-demand data to treatment of water contaminated with chemical warfare agents.

2. There is no clear civil or military guidance on how to conduct the vulnerability portion of the emergency water planning.

a. In the public sector, a water vulnerability study is a step in a larger process of emergency water planning. Emergency water planning includes everything from identifying and describing the water system by component part to having an emergency communication net for recalling water treatment plant personnel.

Note: This report was accomplished by the Air Force Occupational and Environmental Health Laboratory (AFOEHL), which is now the Armstrong Laboratory, Occupational and Environmental Health Directorate.

b. In their draft program "Air Force Energy Vulnerability Assessment Guide," the Air Force Civil Engineering Community, HQ AFESC/DEMM calls for no special Director of Base Medical Services (DBMS) or BEE involvement beyond the inclusion of the medical facility as another functional area. The basics of the guide are discussed in this report. The final document will present base CE with a detailed, systematic method for evaluating and upgrading vulnerable elements in the main base water distribution system.

c. Employment site vulnerability studies, whether to fixed or field locations, share the same elements as studies for main bases. The acknowleged expert and source of technical material presented concerning field locations is the US Army. Employment sites include colocated operating bases, forward operating locations, bare base operations, second echelon medical support, etc.

3. The most prudent course of action for the BEE is to conduct the portions of emergency planning which have historically been BEE responsibilities and closely interact with civil engineers to provide technical advice on all other aspects of the program. The BEEs historical responsibilities include, but are not limited to, monitoring for potability and maintaining and operating the associated equipment, making recommendations concerning treatment alternatives, inspecting and approving water sources and water treatment methods and procedures, and recommending the use of lower quality water in emergency situations. At employment locations, interaction with civil engineers could include civil engineers, planners, and medical personnel from other services and the host nation. The BEE should be involved in other CE aspects of the program to include providing technical review and comment on the following:

a. Vulnerability of water supply and distribution system.

b. Evaluation of the impact of water supply disruption on mission.

c. Proposed corrections to vulnerable components of the water supply and distribution system.

d. Exercise evaluation of base or site water supply sytem.

e. Implementation of remedial actions.

f. Host nation, joint, and other support service agreements pertaining to potable water.

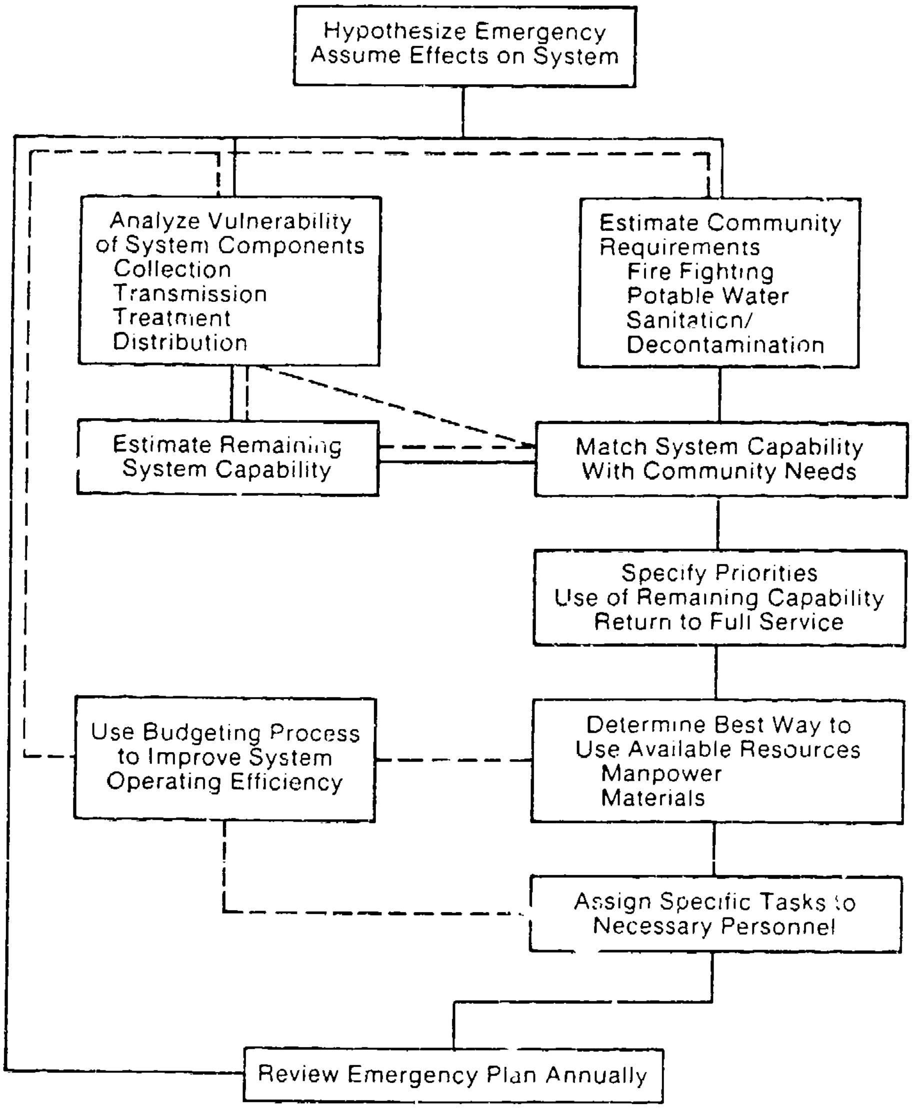


Figure 1. Steps in Emergency Planning (1)

B. Vulnerability Assessments

1. The American Water Works Association has developed a systematic approach for vulnerability analysis which is presented here for reference by base BEEs and Civil Engineers. The approach consists of six steps described below and illustrated in Figure 1:

Step 1. Identify and describe the water system by component part.

Step 2. Assign characteristics to each event to be evaluated.

Step 3. Estimate the effect of each event on each component.

Step 4. Estimate the water demand following the event.

Step 5. Estimate the shortfall by comparing demand (Step 4) with supply (Step 3).

Step 6. Identify which components of the water system were primarily responsible for the shortfall.

a. Identification and Description of the Water System by Components

(1) This step of the vulnerability assessment will produce a matrix which shows the relationship between critical factors of the water system (e.g., power) and the components of the water system (e.g., a booster station). Tables 1 and 2, Water System Factors and Components -- Ground and Surface Water Supply, show the relationship between water supply factors and system components for ground and surface water supply respectively. Table 1 shows, for example, that the factor power supply will effect wells, chlorine station, and booster station. However, power will not effect the reservoir or piping, and may or may not effect the operation of valves.

Table 1. Water System Factors and Components -- Groundwater Supply (2)

	System Components*					
				Distribution		
Factor	Wells	Chlorine Station	Booster Station	Reservoir	Piping	Valves
Power supply	x	x	x			-
Structure (housing)	-		-			
Control system:				-		
manual	x	x	x	-	x	x
automatic	-	-	-	-	-	-
telemetry	-		-	-	-	-
Booster station		-		-	-	-
Receiving system:						
reservoir	-		-	-	x	
distribution system	x		x	x		
treatment plant	-		-	-		
Inlet (suction) piping	x	x	x	x		x
Discharge piping (downstream)	x	x	x	x		x
Special Structures:						
valve vaults	-		-			-
valve supports	-		-			-
pipe supports	-		-			-
Downstream system pressures	x		x	x		x
Valves:						
gate valves	x		x	x		
check valves	x		x	-		
pressure-reducing valves	-		-			
air-relief valves	x		-	-		
Downstream water demand	x	x	x	x	x	
Laboratory facilities	-	x				
System layout(looping)	-		x		x	x
Chemicals:						
supply	-	x				
containers	-	x				
feed equipment (Cl2 station)	-	x				
Well supply		x	x	x	x	
Sand settling basin (Noncritical component)						
Personnel	x	x	x	x	x	x
Access to component	x	x	x	x	x	x
State of repair (age, maintenance)	x	x	x	x	x	x
Groundwater level	x					
Communications	x		x	x		

*x denotes that a particular component is dependent on that particular factor for proper operation;
- denotes that the component may be dependent on that factor, subject to details of the particular system.

Table 2. Water System Factors and Components -- Surface Water Supply. (2)

	System Components*				
Factor	Booster Station	Treatment Facilities	Distribution Reservoir	Distribution System	Diversion Structure
Power supply	x	x			-
Structure (housing)	-	x			
Control system:					
manual	x	x	x	x	x
automatic	-	-	-		-
telemetry	-	-	-		-
Booster station		-	x		-
Receiving system:					
reservoir	x	-			-
distribution system	x	-	x		
treatment plant	x		-		-
Inlet (suction) piping	x		x		
Discharge piping (downstream)	x		x		
Special structures:					
valve vaults	-	-		-	-
pipe supports	-			-	-
Downstream system pressures	x		x	-	
Valves:					
gate valves	x		x	x	x
check valves	x			-	-
pressure-reducing valves	-			-	
air-relief valves	-			-	
Downstream water demand	x	x	x		-
Laboratory facilities		x	-	-	
System layout (looping)					
Chemicals:					
supply		x			
containers		x			
feed equipment		x			
Source:					
reservoir or lake or	-	-			-
stream	-	-			-
Diversion works	x	x	x	x	
Raw-water transmission piping	-	x		x	-
Personnel	x	x			-
Access to component	x	x	-		-
Logistics	x	x		x	x
Communications	x				x
Maintenance level	x	x	x	x	x

*x denotes that a particular component is dependent on that particular factor for proper operation;
- denotes that the component may be dependent on that factor, subject to the details of the particular system.

Table 3. Disaster-Effects Matrix. (2)

	Plant (Construction) Damage	Watershed Damage	Reservoir Damage	Storage Tank Damage	Broken Mains	Contamination	Power Outages	Communication Disruption	Transportation Failure	Employee Shortages
Earthquake	•		•	•	•	•	•	•	•	•
Hurricane	•			•	•	•	•	•	•	•
Flood	•		•		•	•	•	•	•	•
Tornado	•			•		•	•	•	•	
Tsunami						•	•	•	•	
Riots, etc	•	•	•	•	•	•	•	•	•	•
Nuclear attack	•	•	•	•	•	•	•	•	•	•
Spills	•	•	•	•		•			•	•
Sabotage	•	•	•	•	•	•	•	•	•	•
Conventional attack	•		•	•	•		•	•	•	•
Biological attack		•				•		•		•
Chemical attack		•				•		•		•

(2) Table 3, Disaster-Effects Matrix, summarizes the impact of a number of disasters on the major components of a water supply system.

b. Identifying Emergencies and Assigning Characteristics

(1) It is usually obvious which emergencies the base should plan for. If the local area has tornadoes, the base should do an assessment for tornadoes. If the base is on a fault line, they should do an assessment for earthquakes. Air Force plans should include sabotage, biological, chemical, conventional, and nuclear attack.

(2) The characteristics of many natural disasters are well documented. Bases should consult local records for details. Each state should have an emergency management office and a Hazard Vulnerability Analysis for Local Jurisdiction. Cities or counties will have emergency coordinators who may also be able to provide information.

(3) The characteristics of sabotage and attack must be assumed in many cases. Listed below is some general and, for the most part, common sense planning information.

(a) Destruction of facilities by sabotage or conventional attack is similar to planning for earthquake or tornado natural disasters.

(b) Either sabotage or chemical/biological attack could introduce toxics into the base's water supply. The list of possible toxic agents effective in water is limited by the quantity which the enemy or saboteur would have to introduce into the system to generate lethal levels, the solubility of the chemical and the detention time in the water system. Table 4, Potential Acute Toxic Agents in Drinking Water, shows the concentration of some toxics that would pose an acute hazard.

Table 4: Potential Acute Toxic Agents in Drinking Water (2).

Agent	Concentration (MG1)
LSD2	0.050
Botulinus toxin3	0.001
Staphyloccoccus-entertoxins4	0.05
Nerve Agents4	50
Arsenic*5	100-130
Cyanides4	25
Fluoride (sodium Fluoride)4	3000
Cadmium*5	15
Mercury*5	75-300
Dieldrin6	5000

1 Based on the ingestion of 500 mL (16 oz) of water.
2 Jour. AWWA, pp 120-122 (Jan. 1967)
3 WHO (1970)
4 Bell, Frank. A. Letter Report (Apr. 1972).
5 McKee, J.E. & Wolf, H.W. Water Quality Criteria, Calif. State Water Quality Control Board. Pub. No. 3-A (1963).
6 DuBois, K.P. Insecticides, Rodenticides, Herbicides, Household Hazards. Information Circular on Toxicity of Pesticides to Man. WHO, No. 2 (Jan 1959).

1 Chemical warfare agents of concern include the nerve agents sarin, soman, and VX; blister agents mustard and Lewisite; the blood agent hydrogen cyanide; and a choking agent, phosgene. Biological agents of concern include anthrax, tularemia, plague, cholera, botulinum toxin, enterotoxin and mycotoxins.

2 The most effective chemical warfare agents for water contamination, in order of effectiveness, are nerve agents, Lewisite, mustard, and hydrogen cyanide. Sodium cyanide or potassium cyanide are three orders of magnitude less toxic than the nerve agents. Mustard agents hydrolyze in water making them less effective. Nerve agents are highly water soluble and very toxic. VX is the most toxic of the nerve agents as it dissolves and hydrolyzes slower in water than sarin and soman, and produces toxic hydrolysis products. (4)

3 In general, biological agents include toxins and microbes transmitted by a water vector. Symptoms from these agents may not appear until up to 10 days after their ingestion. (3)

(c) Radioactive particle contamination and fallout. External, whole-body exposure to gamma radiation will be the predominant radiological hazard following a nuclear explosion. About 90% of the nuclear radiation from fallout is beta. Beta is a significant skin hazard. Alpha originates essentially from unfissioned nuclear material. Since both alpha and beta have limited penetrating ability, they are considered to be primarily internal hazards. Consequently, water source contamination by fallout will be a secondary problem.

1 The major contributors to the total body dose can be divided into groups. Group 1 is iodine 131, a problem only for the first few weeks because it has a relatively short half-life. The target organ for iodine is the thyroid. Group 2 includes strontium-89 & 90, cesium 137, and barium-140. Due to their long half-lives, they persist for years and are the most significant problem of long-term fallout. Group 3 includes cesium-144, yttrium-91, and other related rare earth elements. These have a similar impact to the Group 2 elements, but are less pervasive. Finally, Group 4 includes activated materials from the weapon like zinc, copper, magnesium, and iron which are a concern only in early fallout. All ingested nuclides contribute to doses of the GI tract in transit. (4)

2 Thyroid dosage from I-131 is over 500 times greater than total body absorbed dose and 50 times the large intestine and bone dose. This value can be reduced by a factor of 3 with a two-week delay in consuming the contaminated water. This is especially important for infants with a higher thyroid activity. The two-week delay does not significantly reduce the large intestine, bone and total body dose because of the longer half-life of nuclides effecting those organs. (4)

3 Fallout particles vary in size from several to several hundred micrometers.

4 The particles have a specific gravity similar to sand and 80% of the radioactivity is associated with particles 50 micrometers and larger. Only 5-10% of the radioactivity is soluble, and the decay is dramatic during the initial hours and days following a nuclear explosion. (2)

5 Groundwater sources should remain uncontaminated, but could become contaminated prior to consumption, e.g., by transmission through a contaminated distribution system, storage in an open reservoir, etc.

c. Estimating Event Effect on Water System Components

(1) This portion of the vulnerability assessment calls for an evaluation of each disaster or event being considered on the various components of the system. This requires completion of a vulnerability analysis worksheet similar to Figure 2, Vulnerability Assessment Analysis Worksheet. (The Appendix contains examples.)

BASE VULNERABILITY ASSESSMENT ANALYSIS OF DISASTER EFFECTS BY COMPONENT

DISASTER: DATE:

SUMMARY OF DISASTER: ____________________________________

COMPONENT	NONE	EFFECTS OF DISASTER PARTIAL	TOTAL	TYPE & EXTENT	CORRECTIVE MEASURES
SOURCE					
COLLECTION WORKS					
TRANSMISSION SYSTEM					
TREATMENT FACILITIES					
DISTRIBUTION SYSTEM					
PERSONNEL					
POWER					
MATERIALS & SUPPLIES					
COMMUNICATION					
EMERGENCY PLANS					

Figure 2. Vulnerability Assessment Analysis Worksheet.

(2) The worksheet documents the effect each event would probably have on each component of the water supply system, i.e., none, partial, or total. It also calls for a description of the type and extent of the effect and potential corrective measures.

d. Water Demand Following the Design Event

(1) Water demand is the sum of the requirements for personal use, firefighting, water system delivery losses, and critical industrial and operational requirements. There is additional "demand" created by broken mains and transmission lines.

(a) The demand from the damaged system(s) will exist until water plant personnel can valve off transmission lines and make necessary repairs. Complete restoration of the distribution system could take weeks.

(b) The civil potable water demand during initial restoration is approximately 38 liters/day per person.(2) When determining the supported population, water planners need to include additive forces and exclude noncombatants. Table 5, Recommended Water Consumption Planning Factors, shows US Army Field Manual 10-52 consumption planning factors. (5)

Table 5: Recommended Water Consumption Planning Factors (5).

(gallons per person per day)

Part 1: Company Level Temperate Zone

Function	Sustaining	Minimum
Drinking	1.5	1.5
Personal Hygiene	1.7	0.3
Field Feeding	0.3	0.8
Subtotal	3.5	2.6
+10% waste	0.4	0.3
Total	3.9	2.9

Part 2: Company Level Tropical & Arid Zones

Function	Sustaining	Minimum
Drinking	3.0	3.0
Personal Hygiene	1.7	0.3
Heat Casualty Treatment	0.2	0.2
Field Feeding	0.3	0.8
Subtotal	5.2	4.3
+10% waste	0.5	0.4
Total	5.7	4.7

Part 3: Company Level Arctic Zone

Function	Sustaining	Minimum
Drinking	2.0	2.0
Personal Hygiene	1.7	0.3
Field Feeding	0.3	0.8
Subtotal	4.0	3.1
+10% waste	0.4	0.3
Total	4.4	3.4

(c) AFM 88-10, Water Supply, Water Supply for Fire Protection, Chapter 6, describes firefighting requirements. Requirements range from a two-fire capability of 1,000 gallons per minute (gpm) for 4 hours with a 10 pounds per square inch (psi) residual for a large base, to 150-250 gpm for 2 hours at a small base. (6) Base planning figures should be readily available.

(d) Essential industrial or war-fighting requirements may exist on base. The photo laboratory dilution water requirements at a wing with a reconnaissance mission might be an example of an essential industrial requirement. Bases with depot level maintenance may have additional water requirements.

(e) Decontamination requirements are those for water for decontaminating vehicles, buildings, and personnel following chemical or nuclear attack. These requirements are difficult to quantify and sources of decontamination water may include water from adjacent communities. The base may be able to make local agreements to obtain off-base decontamination water. Planning should incorporate base plans for decontamination sites off-base, at second-echelon hospitals, etc.

(2) Since the water demand will vary depending on the emergency, public sector emergency planning suggests generating a water demand curve for each scenario similar to Figure 3, Water Demand under Normal and Emergency Conditions.

(3) Water quality is an important aspect in the water demand equation. The actual potable water demand may be quite limited and the water quality criteria for short-term exposure is less stringent than the day-to-day criteria directed by the Safe Drinking Water Act. It is also essential that base medical personnel have information on acceptable water contamination levels for chemical agents not regulated for the general public. Table 6, Emergency Potable Water Limits, summarizes short-term limits and recommended limits for contaminants the base might be concerned with during conflict.

Table 6: Emergency Potable Water Limits (mg/l)

Chemical	Emergency Short Term (3-days)a	Short Term (7-days)b	Long Term
Aldrin	0.05		0.032a
Arsenic		2.0	0.05c
Berylium	0.1		0.001c
Boron	25.0		1.0a
Chlordane	0.06		0.002c
Chloride			600b
Cyanide	5.0	20.0	0.2c
DDT	1.4		0.04b
Dieldrin	0.05		0.017a
Endrin	0.01		0.002c
Ethylene Chlorohydrin	2.0		
Heptachlor	0.1		0.004c
Heptachlorepoxide	0.05		0.002c

Hydrogen Cyanide		20.0	2b
Lindane	2.0		0.0002c
Magnesium			150b
Methoxychlor	2.8		0.4c
Mustard		2.0	2.0b
Nerve Agents		0.02	
Organiphosphorus and carbamate pesticides	2.0		0.100a
Radionuclides			
Beta Particle and Photon Radioactivity			5 mrem(annual)
Gross Alpha Particle Activity			15pCi/Lc
Radium-226 plus Radium-228			5pCi/Lc
Radon			200-2000pCi/Lc
Total Dissolved Solids			1500
Toxaphene	1.4		.005c
Trinitrotoluene	0.75		0.005
Turbidity		Reasonably clear	1-5(tu)c
2,4-D	2.0		0.07c

Notes: a. AWWA Emergency Planning for Water Utility Management. (2)
b. AFR 161-44, 29 May 79. (7)
c. Safe Drinking Water Act Maximum Contaminant Level or Proposed MCL.

e. Estimating the Shortfall by Comparing Demand with Supply

(1) Step 5 involves identifying the shortfalls in each design event between the demand and supply for water. One method is to create a day-by-day summary of supply and demand.

(2) It may also be helpful to superimpose a graph of demand for water on the capability of the system to provide the water (Figure 3 and the Appendix). When the amount of water supplied is reduced below the demand, a deficiency occurs. The demand for water will have to be met by off-base sources, or in the worst case situation, not met at all. Repair or decontamination of the water system will allow supply to meet demand some time after the event.

f. Identify Which Components of the System Were Primarily Responsible for the Shortfall

(1) Referring to Step 3, the engineer would create a list of system components that would be partially or totally incapacitated by the assumed disaster. This review will determine the possible weak points in an existing system and allow for a program of physical improvements and plans for emergencies.

(2) Next, systematically evaluate the effect on water supply of placing a single damaged component (or a related set of components) back "on-line." For example, if emergency power had remained working during the event, what would be the effect on water supply?

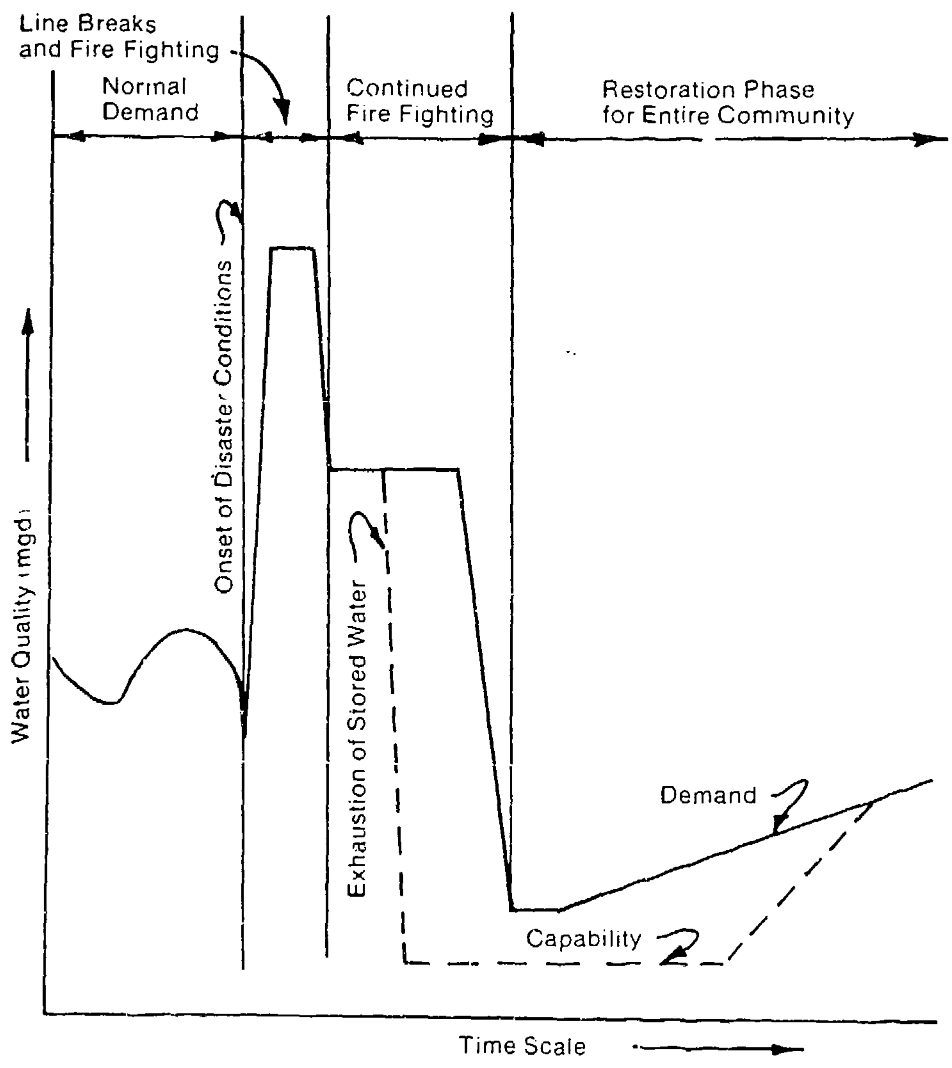


Figure 3. Water Demand Under Normal and Emergency Conditions (2)

(3) Repeated application of this process for each of the design events will identify critical components of the entire water supply system. These components should receive the most attention for improving security, hardening, redundency, etc., discussed in a later section of this report.

C. HQ AFESC Draft Vulnerability Assessment Program

1. HQ AFESC/DEMM is presently working to publish guidance for the Civil Engineering community on vulnerability assessments. The draft document title is the Air Force Energy Vulnerability Assessment Guide (EVAG). The program manager and OPR for the document are Mr Stephen Hathaway and HQ AFESC/DEMM, Tyndall AFB FL 32403-6001. The guide is an updated version of a document written for the USAF in FY 83 by the DOE Los Alamos National Laboratory (LANL), program manager Dr Fred Roach. The guide was published by HQ AFESC as DEB-TR-84-02, and distributed to MAJCOM commanders in 1984. The draft document title is misleading--the scope of the program includes other utilities including potable water.

2. The EVAG follows established contingency planning philosophy of brainstorming problems to arrive at solutions unique to the base or site in question. It is intended to apply to all levels of conflict and peacetime contingencies including natural disaster, terrorism, sabotage, low-intensity conflict, conventional war, and nuclear war. It applies to CONUS and overseas operations and includes chemical, biological, and radiological warfare environments. The scope encompasses mission-related off-base vulnerabilities and includes provisions to implement remedial deficiencies including planning, programming and budgeting steps.

3. The EVAG is a six-phased, base-wide process. Phases I-IV would take about 17 weeks. Phase V covers the year following completion of Phases I-IV. Phase VI is intended to be an ongoing process. CE estimates the contractual cost of Phases I-IV to range from $20,000 to $90,000. The phases are described in more detail below.

a. Phase I: Determine the vulnerability of the off-base water supply and distribution system. This phase includes a number of sub-tasks.

(1) Determine peacetime and wartime water needs.

(2) Review contracts and sources of off-base water supplies.

(3) Develop a checklist for off-base water supply assessment.

(4) Communicate with off-base suppliers.

(5) Conduct assessment workshop as a sub-group of the EVAG.

(6) Document findings, Annex N of the Base Recovery Plan and in a Phase I point paper.

b. Phase II: Determine the vulnerability of the on-base supply, storage, and distribution system. This phase's sub-tasks are outlined below.

(1) Determine peacetime and wartime water requirements of mission essential facilities.

(2) Identify the on-base water supply for each essential facility.

(3) Develop a checklist for on-base water supply assessment.

(4) Correlate mission-essential facilities and the water systems which serve them.

(5) Develop water disruption scenario.

(6) Conduct a water assessment workshop. Consider identification of key hardware components, analysis of possible actions to disable the components, and capabilities to resume service or supply.

(7) Document findings.

c. Phase III: Determine the impact of water disruption on wartime and peacetime missions.

(1) Evaluate the impact of water disruption on host and tenant organizations.

(2) Conduct an assessment workshop.

(3) Document findings.

d. Phase IV: Integrate and document findings, recommendations, and plans for remedial actions to correct any deficiencies. This phase produces a single integrated report describing the base's overall vulnerability, expected consequences, results of exercise, and corrective or remedial actions.

e. Phase V: This phase is the validation phase. Evaluate mission support capabilities and completed and proposed remedial actions through exercise. The threefold objective of this phase is to determine the capability to support mission during water disruption, validate completed actions to correct any water security deficiencies, and to help prioritize planned remedial actions.

f. Phase VI: Implement on a continuing basis all remedial actions required to ensure mission support.

4. The EVAG calls for establishing a working group chaired by the vice commander and including representatives from all tenant and host activities including OPRs for base OPLANS. This group could meet as a subgroup to the base's existing Energy Steering Group, or the Air Base Operability Group.

5. Much of the threat information in the EVAG is derived from the SALTY DEMO exercise at Spangdahlem AB, Germany. This exercise indicated that more than 250 utility disruptions could be expected for an eight-attack

conventional/chemical scenario in Europe. The Civil Engineering Research Division of the Air Force Weapons Laboratory (AFWL/NTE) predicted 188 large munition craters during the eight-hour attack scenario for Spangdahlem. These included large munitions craters involving 5 8-inch water mains, 18 4-inch feeders, and 6 2-inch feeders. Other sources of threat information are the (S/NF/WNINTEL) Worldwide Non-nuclear Threat to Airbases (U) available from HQ AFIA/IN, base-level plans like the base support plan, the base war and mobilization plan, and base and MAJCOM IN staffs.

6. The EVAG points out that most existing utility systems are not hardened, redundent, or dispersed, and that repairs to utility systems do not meet Base Recovery After Attack timing criteria. One purpose of a complete EVAG is to reveal specific areas where improvements are needed. The EVAG predicts a degradation of sortie generation capability from the loss of water storage and distribution system. It states studies have clearly defined the loss of hydrant water following the first attack of the conflict as the single most crucial impact of broken water mains on firefighting capability. The loss of fire suppression capability creates a two-fold system vulnerability--loss of POL reserves, and unattended POL fires are a clear-cut infrared beacon for enemy aircraft.

7. The EVAG also has a rating system for deficiencies ranging from "critical," where effective wartime operations cannot be conducted unless the facility or system is in operation, to "enhancement," where the facility or system provides a needed step toward full capacity.

D. Employment Site Vulnerability Assessments

1. Fixed facilities present evaluation problems similar to those faced at main operating bases, and CE and BEE personnel should approach emergency potable water planning for them both in a similar way. Coordination and meeting with the interested parties at employment sites will be more difficult and documentation of the assessment results will have to be incorporated into host-nation or other support documents.

2. Operational plans detail which employment sites the base and its tenants support. Sites include colocated operating bases (COBs) and forward operating locations (FOLs). The CONUS or overseas base tasked to provide medical and civil engineering base operating support for the employment site may be different from the base deploying operational unit packages. When this occurs, the BEF should get MAJCOM clarification as to which sites the BEE will support. (Exercise good security practices and do not discuss or talk around classified material on unclassified lines.)

3. BEEs at main bases may be tasked to support a variety of field facilities, for example second echelon hospital, tactical air control center, or a bare-base operation. Vulnerability studies at these sites can follow the same problem solving approach used at main bases or fixed employment sites.

E. Protective Measures

1. Protective measures encompass a wide range of actions falling under the responsibility of many base agencies. They may be implementable locally or require long term planning and budgeting. Protectiv measures are

included in this report as a shopping list of actions which each base should consider implementing to reduce the water system vulnerability. These measures should be implemented through civil engineering as part of their emergency planning program for potable water. The BEE should provide technical comments and suggestions.

a. Communications. As Figure 4, Essential Communications, shows, adequate communications need to exist at many levels. The six essential communication nets that must exist are described below. The protective measure for each is to have a radio net backup to telephone communication and to have provisions for runners and the associated manpower and transportation when communication outages occur.

(1) Net 1, plant must be able to communicate with plant personnel.

(2) Net 2 requires telemetry to automatic signal equipment at pump stations, elevated reservoirs, intakes, treatment works, shutoff valves, etc. The protective measures include a pre-coded automatic operating schedule in the event of signal failure.

(3) Net 3 requires communication between medical water monitoring teams or automated sites and the plant and command post.

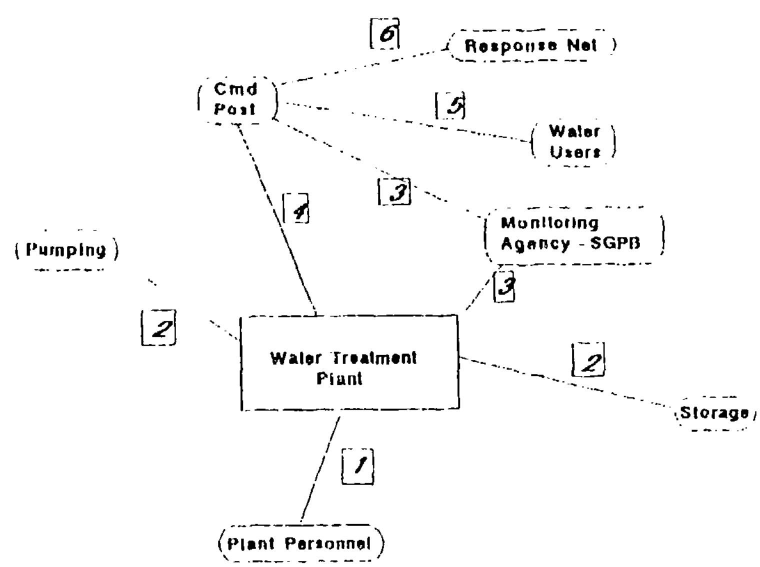


Figure 4: Essential Communications

(4) Net 4, plant to command post or other authority communication, e.g., Survival and Recovery Center command post civil engineer cell.

(5) Net 5, the command post must be able to communicate water status rapidly to remote users and other subordinate command posts. The base loudspeaker system is a good communication backup.

(6) Net 6, command post to civil or higher command response net, e.g., local disaster response, or national response nets for consultation and assistance.

b. Security. Security includes fencing and/or locking plants, well heads, storage towers, surface sources (where practicable), and other critical parts of the water collection, treatment and distribution system. The base should install protective lighting at key points. Security Police should plan for increased surveillance at appropriate times. Water plant personnel should meet and escort all visitors. All employees should have identification cards. Plans should restrict or deny access to on-line reservoirs. Civil engineering should seal off manholes within six blocks of critical locations and provide 24-hour manning at treatment plants.(2)

c. Detection and Monitoring

(1) The majority of chemical agents cause secondary taste, color, odor or chlorine demand effects. Biological agents will generally not create a taste, color or odor and are more difficult to directly detect (e.g., botulinum toxin). Utility operators may be able to instantly recognize many subtle changes caused by sabotage or attack.

(2) Each base should have a plan to increase water monitoring frequency during increased readiness as described below. Medical (Bioenvironmental Engineering Services) personnel should plan on monitoring the water source or sources, water in key loops of the distribution system serving operations centers and command post water.

(3) Environmental Health medical personnel should have a program to scrutinize patient trends which might point to a water-borne etiology. Patients presenting symptoms may be the first indication of contaminated water, since no field detection devices are available for many potential contaminants, and there are so many potential agents.

(4) Monitoring should include 24-hour bacteriological monitoring. Medical personnel should speciate all colonies.

(5) Plans should call for early initiation of chemical agent monitoring using the M 272, Water Testing Kit, Chemical Agents. This kit (NSN 6665-01-134-0885) checks for nerve, blood and blister agents. Table 7, M272 Detection Limits, shows the sensitivity of the kit. There is no Air Force document describing the kit's use. Army Technical Manual 3-6665-319-10, 30 Nov 1983 does describe how to use the M272. (8) The USA Munitions and Chemical Command, ATTN: DRSMC-M4S-C, Aberdeen Proving Ground MD 21010 publishes the document.

(6) Continuous biological monitoring systems exist and several larger cities have purchased them for monitoring their source water. In addition, the Army has done research on less sophisticated, but still effective, devices that may be useful for incorporating into the site monitoring plan under certain circumstances. Contact the Bioenvironmental Engineering Division of the Armstrong Laboratory for additional information on these devices.

Table 7: M272 Detection Limits (8).

CW Agent Name	Symbol	Amount* (mg/l)	Remarks
Cyanide	AC	20.0	as CN-
Mustard	HD	2.0	--
Lewisite	L	2.0	as As+3
Nerve	G/V	0.02	--

d. Water Treatment

(1) Perhaps the most important countermeasure for chemical or biological contamination is maintaining a high chlorine residual. Table 5-1 of AFR 161-44, requires 0.2 mg/l of residual chlorine when bactericidal contaminants are suspected and 10 mg/l of residual chlorine when cysticidal contamination is suspected. (7) The Director of Base Medical Services may prescribe higher or lower chlorine concentrations. These levels will effectively oxidize or destroy a wide spectrum of chemical and biological agents, e.g., infectious hepititus virus, LSD, staphyloccus enterotoxin, and cyanides all react with chlorine in water. (1,5) However, some contaminants are chlorine resistant and a chlorine residual does not guarantee safe water.

(2) Table 8, Emergency Treatment for Reducing Concentration of Specific Chemicals in Community Water Supplies, describes treatment methods for some key chemicals.

Table 8: Emergency Treatment for Reducing Concentration of Specific Chemicals in Community Water Supplies* (2)

Concentration	Treatment
Arsenicals Unknown organic and inorganic arsenicals in groundwater at concentrations of 100 mg/L	Precipitation with at least 2 moles ferric sulfate per mole of arsenic and liming to pH 6.8 followed by sedimentation and filtration. Reported removal, 95 percent. Effectiveness at low as concentrations unknown.

Table 8: Emergency Treatment for Reducing Concentration of Specific Chemicals in Community Water Supplies* (Cont'd)

Concentration	Treatment
Cyanides	Proper chlorination to a free residual under neutral or alkaline conditions will reduce cyanide at very low levels. It should be noted that at a pH of 8.5, cyanide is readily converted to cyanate, which is much less toxic. For raw-water sources, chlorination is followed by coagulation, sedimentation, and filtration.
Hydrocarbons Kerosene peak concentrations of 140 mg/L	The Atlanta water plant used preapplications of bleaching clay (33 mg/L) and activated carbon (7.2 mg/L), plus some increase in normal dosage of alum, chlorine dioxide, lime, and carbon, to provide treatment enabling continued production of water.
Miscellaneous Organic Chemicals LSD (lysergic acid derivative)	Chlorination in alkaline water or water made alkaline by addition of lime or soda ash to provide a free chlorine residual. Two parts free chlorine are required to react with each part LSD.
Nerve Agents (Organophosphorus compounds)	Superchlorination at pH 7 to provide at least 40 mg/L residual after 30-min chlorine contact time, followed by dechlorination and conventional clarification processes.
Pesticides 2,4-DCP (2,4-Dichlorophenol) an impurity in commercial 2,4-D herbicides	Adsorption of activated carbon followed coagulation, sedimentation, and filtration. Laboratory bench studies showed required carbon dosages as follows:

Concentration 2,4-DCP Initial g/L	Final g/L	Required Carbon Dosage mg/L

Table 8: Emergency Treatment for Reducing Concentration (Cont'd) of Specific Chemicals in Community Water Supplies*

Concentration	Treatment
	100 2 5.9 80 2 4.7 50 2 2.9 30 2 1.7
DDT (dichlorodiphenyl-trichloroethane), concentrations of 10g/L	Chemical coagulation, sedimentation, and filtration. Pilot-plant studies indicate 98 percent removal.
Dieldrin, concentrations of 10 g/L	Chemical coagulation, sedimentation, and filtration. Pilot-plant studies indicates 55 percent removal. Supplemental treatment with 20 mg/L activated carbon increased removal to 92 percent.
Endrin, concentrations of 10 g/L	Chemical coagulation, sedimentation, and filtration. Pilot-plant studies indicate 35 percent removal. Supplemental treatment with 20 mg/L activated carbon increased removal to 94 percent.
Lindane, concentrations of 10 g/L	Application of activated carbon followed by chemical coagulation, sedimentation, and filtration. Pilot-plant studies indicate 80 percent removal with 20 mg/L carbon dosage.
Parathion, concentrations of 10 g/L	Chemical coagulation, sedimentation, and filtration. Pilot-plant studies indicate 80 percent removal. Supplemental treatment with activated carbon increased removal to 99 percent. Omit prechlorination as chlorine reacts with parathion to form paraoxon, which is more toxic than parathion.

e. Training. Exercising the base's response to emergencies requires appropriate training be integrated into base disaster response and wartime exercise scenarios. Training reinforces emergency procedures and reveals planning shortfalls. Realistic scenarios challenge base decision makers to allocate scarce personnel, equipment, and water resources in a manner similar to the anticipated situation.

f. Emergency Operations Planning. Each base should integrate their emergency operations plan for potable water into other base planning documents for disasters and contingencies. These plans should incorporate the findings of the vulnerability assessment. Planning should include the elements listed in Table 9, Checklist for Emergency Operations.

Table 9: Checklist for Emergency Operations

- Appointment of responsible planners
- Recall listing
- Contact with civil defense and local emergency operation centers
- Vulnerability assessment
- Prioritization scheme for available water
- Emergency treatment, pumping and distribution
- Establishing control and communication centers
- Primary and backup communications
- Instructions for when other public utilities are unable to meet water plant needs
- Command post and key workcenter notification procedures
- Pre-prepared placards and signs concerning water potability
- Security assessment
- Records necessary to facilitate recovery
- Emergency & water treatment supplies
  Mutual agreements with related utility, service and civil defense agencies
- Interconnections with adjacent systems
- Alert/recall procedures
- Monitoring supplies or plans
- Time-phased post-disaster recovery plan
- Plan to ID and eliminate system deficiencies

g. Emergency Procedures

(1) The base should have a conservation plan to reduce consumption and non-essential use of potable water and to conserve water left in distribution and building water lines. The plan should include the requirement to communicate the implementation of various phases of the plan to water users.

(2) Water plant personnel should maintain a stockpile of water treatment and disinfection chemicals as well as stocks of critical spare parts.

(3) Recovery plans should detail how to isolate loops in the distribution system following damage or identification of contamination.

(4) Wellheads should be isolated and protected from submergence or contaminated runoff. All means of injecting contaminants into groundwater should be sealed off or protected (e.g., historical sampling wells).

h. Other Considerations

(1) Civil engineers should design plants with multiple reservoir inlets to intake water from less contaminated strata within the reservoir. Reservoirs should be covered wherever possible.

(2) Design or upgrade the water system to provide sufficient on-line reservoirs and gravity flowlines to maintain limited distribution in the event of power failures. Purchase and make available portable generators capable of being moved to intake structures and pumping stations.

(3) Establish an agreement with local power companies for priority power.

(4) Locate facilities away from fault zones, out of floodplains, or protect them with adequate berms. Flexible coupling and redundent systems should be considered over faults and in especially critical areas. Shorter pipe length made of steel or ductile iron will withstand higher attack or earthquake stress. Adequate protection from earthquakes can be achieved with 14" reinforced concrete or the equivalent in walls and ceilings of structures. (2)

(5) Develop backup emergency water sources and include their security in vulnerability planning.

III. CONCLUSIONS

Both the Air Force Civil Engineering proposal and the public-utility emergency planning process have many elements in common. Both describe a process which includes identification of the threat, evaluation of the impact of the threat on the source and distribution system, modification of weak elements of the water-supply system, and fixing the problems. The processes are similar at main bases and employment sites.

There is no regulatory guidance concerning which aspects of the overall program should be included in a water vulnerability study. As written in a draft form, the EVAG will not provide additional, detailed guidance to the BEE.

The best method of delineating the elements of a water vulnerability report is to match historical BEE responsibilities and elements of water emergency planning practiced by the public sector. This approach gives the following elements to the BEE vulnerability study:

- Identify the primary and alternative sources of potable water and the expected volume associated with each.

- Identify potential sources of contamination throughout the system in the emergency scenarios of concern.

- Review and make recommendations on the BEE's ability to monitor the contamination sources of concern in terms of manpower, equipment, communications, and training.

- Review and comment on the appropriateness of water treatment plans for each contaminant of concern to include, if appropriate, an assessment of the sufficiency of stockpiled chemicals for water treatment.

- Review and comment on alternative water treatment plans.

- Review and comment on CE water demand estimates in various scenarios.

- Comment on the extent of BEE involvement in the base's overall water emergency planning process.

- BES should pay particular attention to document classification. They should work closely with security police and plans personnel to familiarize themselves with essential elements of information, classification guidance and classification authority.

IV. RECOMMENDATIONS

BEE personnel play an important technical oversight role in the overall civil engineering emergency water utility planning process and should work closely with the civil engineering community. Base and employment site vulnerability studies required by AFR 160-25 should be limited to those elements of emergency water planning which fall within the scope of the base-level BEE's responsibilities.

REFERENCES

1. AFR 160-25, Medical Readiness Planning and Training (Jan 1986)

2. Jensen, R.G., et al. Emergency Planning for Water Utility Management-Manual of Water Supply Practices, AWWA M19. American Water Works Association (1984)

3. Lee, H. Vulnerability of Municipal Water Facilities to Radioactive Contamination from Nuclear Attacks. Stanford Research Institute, Menlo Park, prepared for Office of Civil Defense, Department of Defense, OCD-OS-63-149, subtask 3110A, (1964)

4. Fargo, J., et al. Chemical Agent Water Detection. Quest Research Corporation, for Systems Acquisition Division, Human Systems Division, HSD-TR-004 (1989)

5. USA Field Manual 10-52, Water Supply in Theaters of Operations (Jul 1990)

6. AFM 88-10, Chapter 6, Water Supply for Fire Protection (Jul 1958)

7. AFR 161-44, Management of the Drinking Water Surveillance Program (May 1979)

8. Army Technical Manual 3-6665-319-10, Water Testing Kit, Chemical Agents: M272 (Nov 1983)

APPENDIX

Sample Vulnerability Assessment

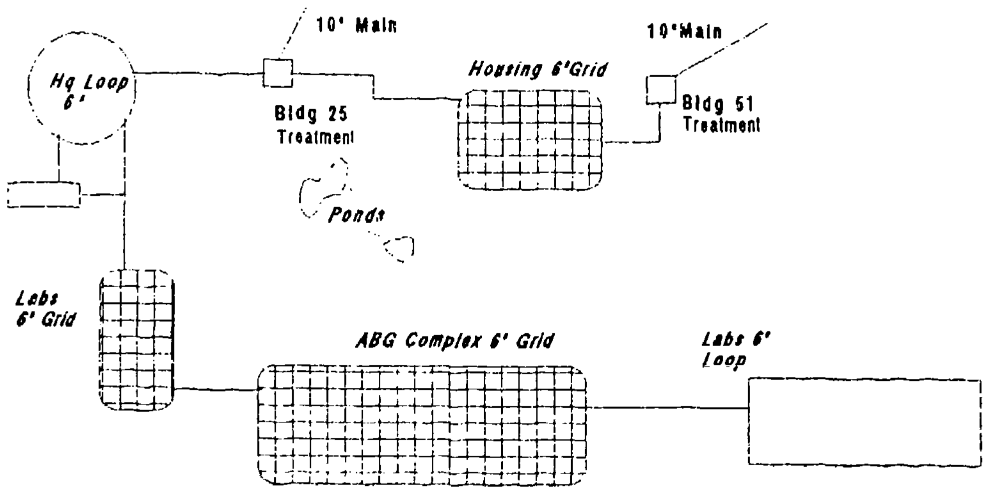
(This page left blank)

Appendix
SAMPLE EMERGENCY WATER PLANNING

(The following example shows a document a base civil engineer might create as part of a CONUS base's emergency planning. The format follows the American Water Works Association's guidance to public utilities.)

STEP 1: Identify and describe separate components of the total water supply system

a. Figure A-1, Base Distribution System, below shows the base's water system.



Base Water Distribution System

Treatment at Bldgs 25 and 51 includes backup chlorination and water conditioning with sodium hexametaphosphate. Bldg 51 also adds sodium fluoride.

Figure A-1. Base Distribution System

General System Characteristics:

Consumption: 0.8 - 1.5 mgd summer
0.4 mgd winter

Population: 3,300 Active duty & Civilian

Fire Demand: 2,000gpm for 4 hours
(0.5 mg)

Alternate Sources: 2 ponds, 2mg
2 pools, 0.4mg

Valves on each block, about every 200 ft

System Pressure: 80 - 125 psi high
65 - 70 psi low

b. Sources: 100% of water comes from local aquifer through the local community water system.

c. Collection works: No on-base collection works.

d. Transmission system:

1. The city delivers water to the base via two ten-inch buried pipelines.

2. Gravity flow system driven by pressure from an off-base water tower.

e. Treatment facilities:

1. Building 25. Backflow prevention device. Hexametaphosphate treatment tank and feeder system. Backup gas chlorination capability. Unattended systems.

2. Building 51. Backflow prevention device. Hexametaphosphate and sodium fluoride treatment tanks and feeder systems. Unattended systems.

f. Distribution system:

1. Normal pressure varies from 90-250 psi at the entry to the base to 65-70 psi throughout the distribution system.

2. Smallest pipes in the distribution loops are six inches.

3. Hydrants are placed approximately 200 feet apart.

4. Grid-type distribution system within each major loop. Valves are located to isolate any block with a maximum of three valves. All valves are manually operated.

g. Personnel

1. Twelve personnel in the plumbing and CE Water Branch provide support for system breaks and operate the treatment facilities.

2. Field crews are adequate for routine maintenance and services, including emergency operations such as isolated main breaks.

3. All major work on the water system is performed by contractors.

h. Power

1. Treatment facilities operate with base power provided by the city.

2. No power produced locally. No backup power.

i. Materials and supplies

1. The base maintains a 60-day supply of hexametaphosphate and sodium fluoride. One 100 gal chlorine tank is on-site for back-up chlorination.

2. Limited plumbing supplies for maintenance and emergency repair are kept on-hand.

3. CE stores all chemical and plumbing materials and supplies in the CE yard on-base.

j. Communications

1. Water personnel communicate using public telephone system. A phone is located in each treatment building.

2. The base has a disaster response/crash radio net which includes the base Civil Engineer, Medical Treatment Facility, and other major organizations on the base. The base can also use the net for upward and lateral communication to higher headquarters and response. Other related on-base response radio nets include medical response and civil engineering response.

3. Water monitoring personnel in BES are not part of the disaster response, civil engineer, or medical response radio nets.

k. Emergency plans

1. Civil Engineering maintains a telephone recall system with which they can call all or selected members of their staff within one to two hours.

2. Civil Engineering contingency and disaster response plans contain limited information on potable water.

3. The Medical Treatment Facility maintains a telephone recall system which will recall all or selected members of BES.

4. Water monitoring planning is not included in MTF plans.

5. The base has held no emergency water drills.

6. Civilian water utility personnel have no emergency plans. Limited cooperation exists between base and civilian water utility personnel.

STEP 2: Assign characteristics to the design disaster(s)

Design disasters applicable to the base include flood from heavy thunderstorms, biological/chemical sabotage, and nuclear warfare.

a. Flood. Heavy thunderstorms generate stormwater runoff across the base capable of causing significant flooding on parts of the base. The flooding area would include both treatment buildings.

b. Biological/chemical sabotage. The base could be the target of biological or chemical sabotage for a number of reasons, primarily from enemy or terrorist action aimed at hampering the base's mission. The contamination would be introduced in such a way as to effect the base but not the surrounding community.

c. Nuclear warfare. The local community will be a likely target should nuclear warfare occur because of its critical defense department

activities. Nuclear attack will make civilian power inoperative and create radioactive fallout. Significant damage to all above ground structures will occur creating numerous breaks in the water distribution system.

STEP 3: Estimate effects of the design disaster on each component

Base Vulnerability Assessment, Step 3: Disaster Effects by Component

Disaster: Flood

Summary of Disaster: Heavy thunderstorms generate stormwater runoff across the base capable of causing significant flooding on parts of the base. The flooding area would include both treatment buildings.

Component	None	Effects of Disaster Partial	Total	Type & Extent	Corrective Measures
Source	X				
Transmission system	X				
Treatment facilities			X	Flooding damage will knock out treatment capability, power, backup chlorination. Corrective Measures: Dike or berm facilities	
Distribution system		X		Washout could occur on the loop of the distribution serving the headquarters and on the connection between the two systems. Infiltration and contamination could occur. Corrective Measures: Additional structural support surrounding these two pipelines would prevent washout. Increase monitoring frequency for color, turbidity, bacteriological screening.	
Personnel		X		Severe flooding will prevent most workers from reporting. Corrective Measures: Cross utilization of available CE workers for support.	

Power			X	Impacts backup chlorination capability. Corrective Measures: Give treatment facilities backup power capability.	
Materials and Supplies	X				
Communications		X		Flood may limit public phone capability and ability to recall personnel; however, personnel may not be able to come to the base in any case.	

Corrective Measures: None

Emergency Plans	X				

Base Vulnerability Assessment, Step 3: Disaster Effects by Component

Disaster: Biological/chemical sabotage

Summary of Disaster: The base could be the target of biological or chemical sabotage for a number of reasons, primarily from enemy or terrorist action aimed at hampering the base's mission. The contamination would be introduced in such a way as to effect the base but not the surrounding community.

Component	Effects of Disaster None	Partial	Total	Type & Extent	Corrective Measures
Source	X				
Transmission system	X				
Treatment facilities		X		Sabotage could cause partial or significant damage to the treatment facility. Also facilities are most likely point to inject contaminants into the distribution system. Corrective Action: Increase security--lighting, physical security, on-site alarms, increased security police monitoring.	

Distribution system	X			
Personnel		X		Insufficient personnel are allocated to monitor potential contaminants. Corrective Action: Modify plans to commit personnel resources.
Power	X			
Materials and Supplies		X		Base may be required to increase chlorination as a precautionary measure for treatment of some chemicals. Adequate monitoring equipment not available. Corrective Action: Insure adequate chlorine supplies are available.
Communications		X		Rapid and clear public notification plans do not exist. Corrective Measures: Incorporate and exercise public notification procedures.
Emergency Plans			X	Contaminating the base's water without effecting the community is practically impossible without a security breach. Support arrangements to analyze additional water monitoring equipment, speciate bacteriological colonies, etc. have not been made. CE & SG monitoring plans are also inadequate. Corrective Measures: Improve security. Make the necessary support arrangements and plans. Exercise procedures.

Base Vulnerability Assessment, Step 3: Disaster Effects by Component

Disaster: Nuclear Warfare

Summary of Disaster: The local community will be a likely target should nuclear warfare occur because of its critical defense department activities. Nuclear attack will make civilian power inoperative and create radioactive fallout. Significant damage to all above ground structures will occur creating numerous breaks in the water distribution system.

Component	None	Effects of Disaster Partial	Total	Type & Extent / Corrective Measures
Source	X			
Transmission system			X	Blast effects will destroy the water tower generating system pressure and transmission of water. Corrective Measure: Conserve and use all available alternative sources of water. Plans should isolate the base's distribution system by closing valves to community. Develop alternative sources of water, e.g., backup well, and associated power and treatment capability.
Treatment facilities		X		Some building damage may occur; however, with the water source cut off at least temporarily, the damage may be irrelevant. Corrective Measures: N/A.
Distribution system		X		Numerous breaks in the distribution system may occur at service connections, or smaller breaks within buildings damaged by blast. Corrective Measures: Valve off damaged structures to conserve water within the distribution system. Repair where practical. Do not contaminate clean water in the distribution system by exposing it to fallout. Initiate radiological monitoring and public information system.

Personnel			X	Manpower will be at a premium due to casualties and other reasons. Corrective Measures: Cross utilization of available CE workers for support.
Power			X	Impacts backup chlorination capability. Corrective Measures: Give treatment facilities backup power capability consistent with plans to develop alternate sources of water.
Materials and Supplies	X			
Communications		X		Radio nets may still operate. Public telephone systems will be inoperative. Corrective Measures: Plan to integrate water communication needs with other base systems and support with runners.
Emergency Plans	X			

STEP 4: Estimate water demand, both quantity and quality

The figures below show the water demand estimates for the base:

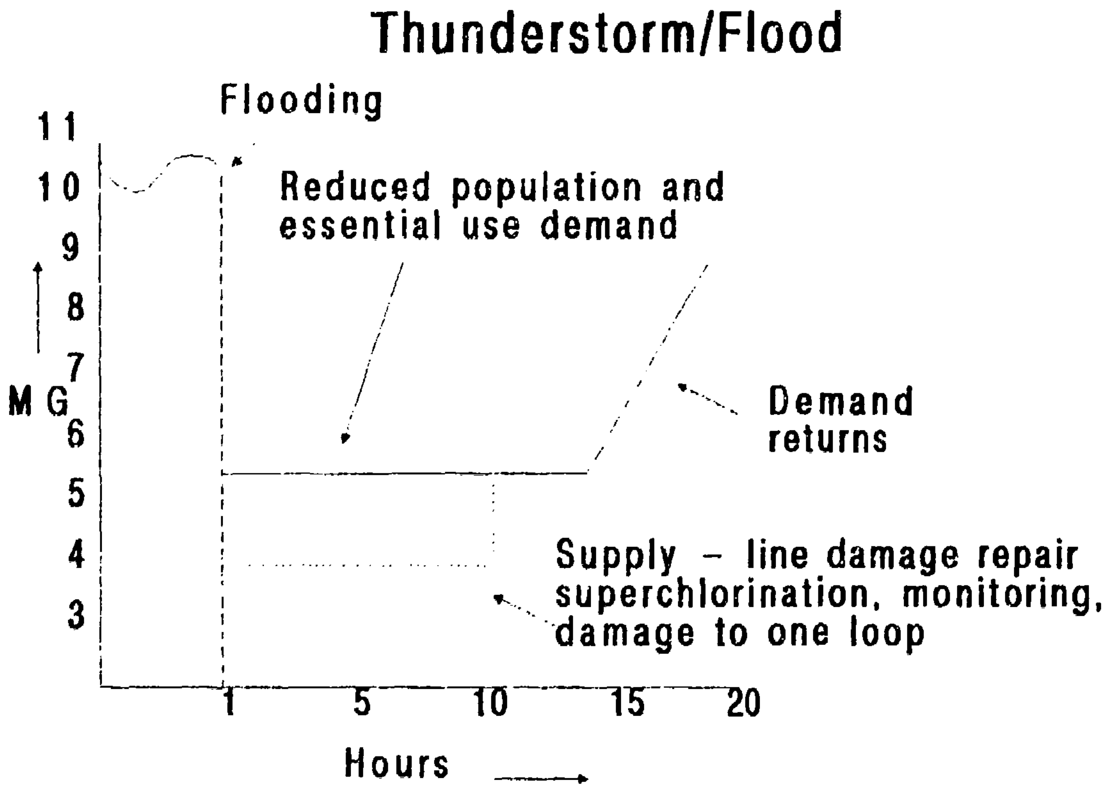


Figure A-2. Thunderstorm/Flood Water Demand Estimate

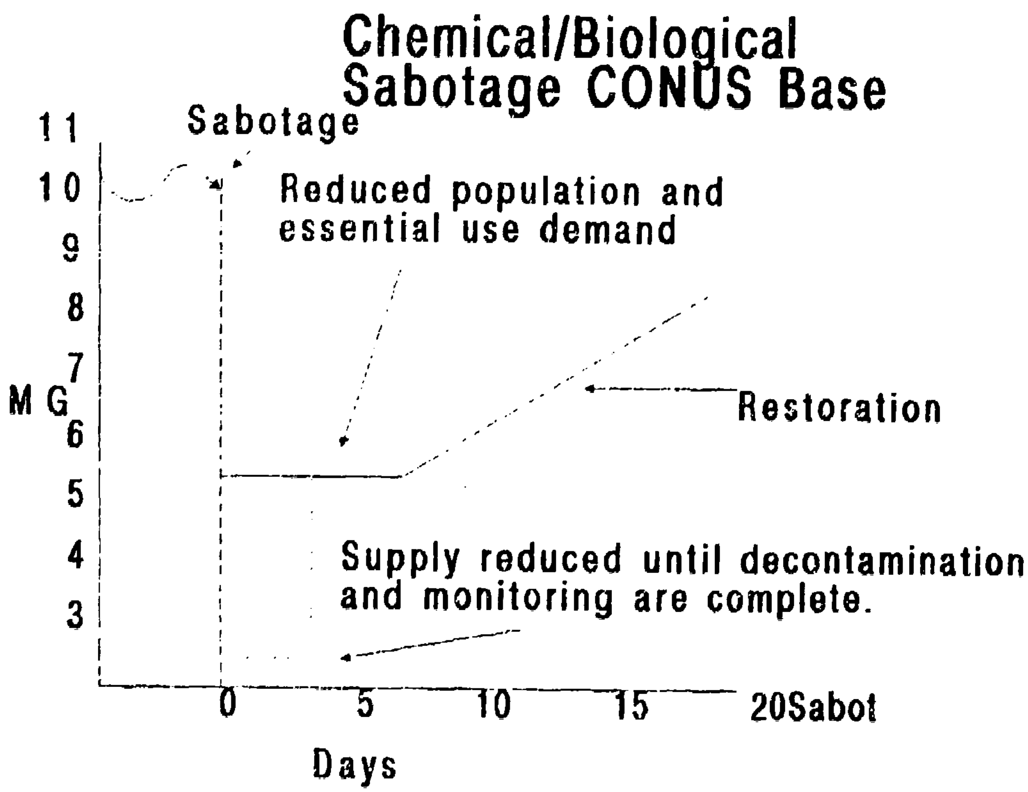


Figure A-3. Chemical/Biological Sabotage Water Demand Estimate

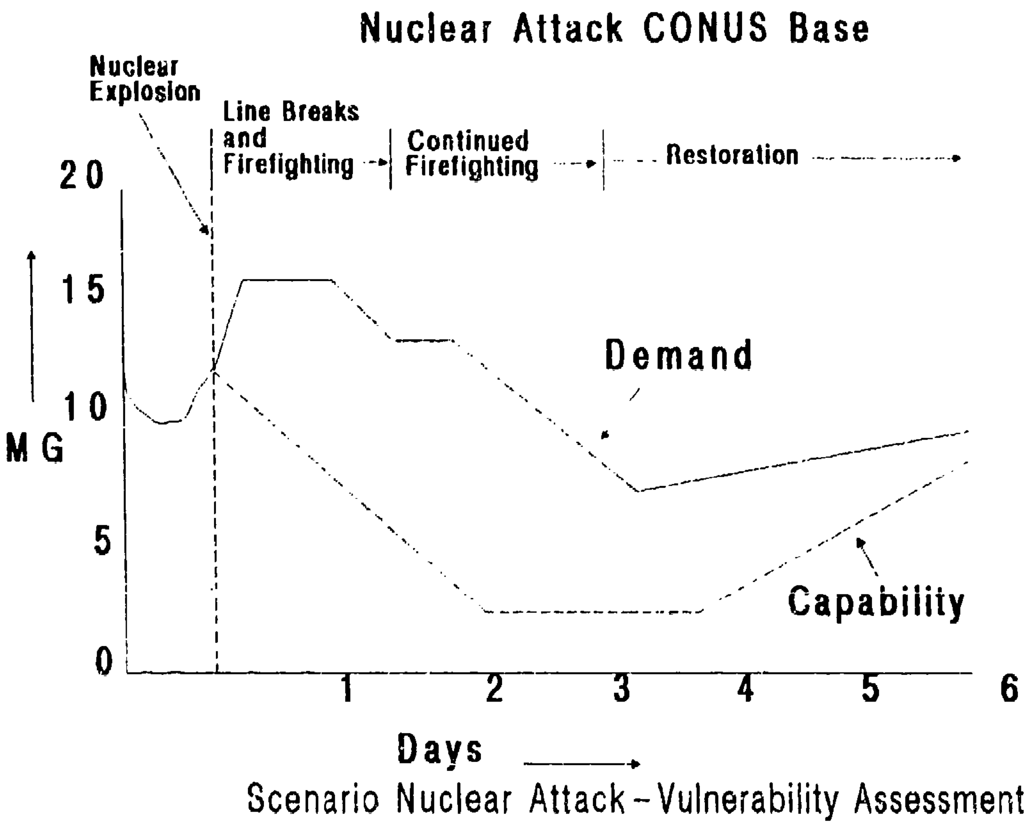


Figure A-4. Nuclear Attack Water Demand Estimate

STEP 5: Review and analyze--does supply meet demand?

a. Supply might not meet demand to some parts of the base in the thunderstorm event either in terms of quantity or quality should a line break. The likelihood that both sources of water to the base will be damaged is more remote. Loop isolation and cross connection with the remaining good source of water on the base should insure potable water to all but small isolated sections of the base.

b. Supply following chemical/biological sabotage will be non-existant in the effected loop(s) until the system can be flushed and decontaminated. The likelihood that both sources of water to the base will be sabotaged is more remote. Loop isolation and cross connection with the remaining good source of water on the base should insure potable water in at least some parts of the system.

c. The city's ability to pump water from the aquifer source will be exceeded shortly after the nuclear explosion event occurs. Demand will exceed supply for some time.

STEP 6: Identify key components primarily responsible for the failure

a. Partially (P) and totally (T) incapacitated components:

	Storm/Flood	Sabotage	Nuclear
Source			
Transmission			T
Treatment	T	P	P
Distribution	P		P
Personnel	P	P	T
Power	T		T
Materials & Supplies	P	P	
Communications	P	P	P
Emergency Plans		T	

b. Component review for weak points.

Storm/Flood: The facility and the backup power for chlorination are the weak points in this scenario. Protecting the treatment facilities from flooding by berming would insure they were protected from the flood. Backup power would insure chlorination capabilities would exist.

Sabotage: The key component in this scenario is the emergency plans which effect the security of the treatment facility. Improved security as part of emergency planning would greatly reduce the occurrence of this event.

Nuclear: A number of components are critical in this scenario including transmission from the city, personnel and power. A backup well source of water would overcome the problem of transmission from the city. Backup power would insure chlorination capability. A pumping system would have to be developed also requiring backup power.

c. Components critical to the water system. The treatment facility protection from flooding and the building security are critical components. Backup power to insure chlorination capability is also a critical component.

Distribution List

	Copies
HQ USAF/SGPA Bolling AFB DC 20332-6188	2
HQ AFSC/DEEV Andrews AFB DC 20334-5000	2
HQ AFSC/SGPB Andrews AFB DC 20334-5000	2
HQ SAC/DEEV Offutt AFB NE 68113-5001	2
HQ SAC/SGPB Offutt AFB NE 68113-5001	2
HQ TAC/SGPB Langley AFB VA 23665-5001	2
HQ USAFE/DEEV APO New York 09012-5001	2
HQ USAFE/SGPA APO New York 09012-5001	2
SD/SGX P.O.BOX 92960 Worldway Postal Center Los Angeles CA 90009-2960	2
HQ PACAF/DEEV Hickam AFB HI 96853-5001	2
HQ PACAF/SGPA Hickam AFB HI 96853-5001	2
HQ AFLC/DEEV Wright-Patterson AFB OH 45433-5001	2
HQ AFLC/SGPB Wright-Patterson AFB OH 45433-5001	2
HQ AFRES/DEEV Robins AFB GA 31098-6001	2
HQ AFRES/SGPB Robins AFB GA 31098-6001	2
HQ ANGSC/DEEV Andrews AFB DC 20331-6008	2

Distribution List (cont'd)

	Copies
HQ ANGSC/SG Andrews AFB DC 20331-6008	2
HQ ATC/DEEV Randolph AFB TX 78150-5001	2
HQ ATC/SGPB Randolph AFB TX 78150-5001	2
AAMRL/TH Wright-Patterson AFB OH 45433-6573	2
HQ MAC/DEEV Scott AFB IL 62221-5001	2
HQ TAC/DEEV Langley AFB VA 23665-5001	2
7100 CSW Med Cen/SGB APO New York 09220-5300	2
Det 3 AL APO San Francisco 96239-5000	2
USAFSAM/TSK Brooks AFB TX 78235-5301	2
Defense Technical Information Center (DTIC) Cameron Station Alexandria VA 22304-6145	2
HQ AFESC/RDV Tyndall AFB FL 32403-6001	2
HQ HSD/XA Brooks AFB TX 78235-5301	2
Each Base Bioenvironmental Engineering Office	1 ea
US Army Environmental Hygiene Agency/HSHB-ME Aberdeen Proving Ground MD 21010-5422	2

* U. S. GOVERNMENT PRINTING OFFICE: 1991--561-052/40041